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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM

FOR THE

STANFORD UNIVERSITY MEETING

AT

STANFORD UNIVERSITY

PASADENA, CALIFORNIA

DECEMBER 19, 1941

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AMERICAN PHYSICAL SOCIETY

STANFORD UNIVERSITY MEETING, DECEMBER 19, 1941

THE 245th meeting of the American Physical Society will be held at Stanford University, California, in the Physics Department, room 372, on Friday, December 19, 1941. Sessions will start at 9:30 in the morning and 1:30 in the afternoon. Members and others in attendance will be enabled to take luncheon together at Stanford Union.

The **Annual Meeting** of the American Physical Society will be held at Princeton from Monday, December 29 to Wednesday, December 31, partly in conjunction with a meeting of the American Association of Physics Teachers. There will be a joint session of the two societies on Tuesday afternoon, at which the following speeches will be given: President G. W. Stewart: "Liquid Structure" (retiring presidential address of the American Physical Society); Professor W. F. Magie: "Joseph Henry"; and Professor A. H. Compton: "Wartime Problems of the Physics Teacher" (first Richtmyer Memorial Lecture of the American Association of Physics Teachers). There will also be a seminar on theoretical physics arranged by the Institute for Advanced Study and held on Monday evening; it will be addressed by Professor A. Einstein and Dr. W. Pauli. The dinner will be held on Tuesday evening.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

After the Princeton Meeting subsequent meetings are planned as follows:

247. February 20–21, 1942. Detroit.

248. April 30, May 1 and 2, 1942. Place either Baltimore or New York.

249. June 17–20, 1942. Pacific Coast Meeting. Salt Lake City.

250. June 25–27, 1942. State College, Pennsylvania.

Sectional Meeting. The secretary of the Southeastern Section of the American Physical Society notifies us that its annual meeting is to be held on April 10 and 11, 1942 in Oxford, Mississippi, at the University of Mississippi.

PAUL KIRKPATRICK,
Local Secretary for the Pacific Coast,
Stanford University, California.
December 4, 1941.

CALENDAR

All sessions will be held in Room 372, Physics Department.

Friday morning, December 19, 1941.
9:30 o'clock. Contributed papers, 1–11.

Friday afternoon, December 19, 1941.
1:30 o'clock. Contributed papers, 12–22.

PROGRAM

FRIDAY MORNING AT 9:30 O'CLOCK

1. Efficiency of Positive and Negative Ions as Condensation Nuclei in the Wilson Cloud Chamber. CARL E. NIELSEN, *University of California.*—It is necessary to know the correlation between droplets formed and ions present if the count of droplets in the cloud chamber is used to determine ionization. The droplet to ion ratio f is dependent upon the expansion ratio x, the sign of the ions, and the composition of the vapor. Curves representing the dependence of f upon x have been obtained experimentally for ions of both signs for three different ethyl-alcohol and water mixtures. The experimental results are well represented by the relation $\ln(1-f) = -te^{bx}$, in which t and b are constants related to the sensitive time of the chamber and the properties of the gas and vapor used. With mixtures not too far from 70 percent ethyl alcohol, all positive ions serve as condensation nuclei when negative ions begin to be effective. If a field is used to separate positive and negative ions, the presence of a negative track is evidence that all positive ions are represented by drops in the positive track.

2. Electrons and Heavier Particles at 14,125 Feet. WILSON M. POWELL,* *Kenyon College, Gambier, Ohio.*—In 200 cloud-chamber photographs under 1.27 cm of iron and 1 cm of lead there appear 985 tracks when the chamber is operated at random. Two hundred seventy-nine tracks could not be identified. Of 706 tracks 565 or 80 percent were electrons and the remainder were heavy particles. If the number of electrons is assumed to be increased by a factor of ten in passing through the lead and iron this indicates that 29 percent of the incoming rays are electrons. Fourteen particles show heavy ionization. Thirty photon produced pairs and 10 electron produced pairs appear. A possible explanation for this large number of photon pairs may lie in the stronger absorption of the electrons at this energy.

* Guggenheim Fellow at the University of California.

3. An Efficient Green Line Source. J. KAPLAN, *University of California at Los Angeles.*—A preliminary report of the most intense green line tube to be discovered so far was made by the author at the Pasadena meeting. The tube contains 100 mm N_2 and small amounts of oxygen generated by heating $KMnO_4$. The beautiful green color of this afterglow shows how great the efficiency of green line excitation is. The change in the spectrum of the afterglow with time, reported earlier by the author for the 3466 line of nitrogen, can be observed visually, by noting the change in the color of the glow, or through a direct vision spectroscope. The first positive bands practically disappear in about three seconds, while the green line persists for about 20 seconds. The forbidden lines of oxygen λ5577 and λ2972 appear to last longer than does the λ3466 line of nitrogen. After the first two or three seconds the tube becomes a monochromatic source of λ5577 in the visible and practically a dichromatic source of λ3466 and λ2972 in the near ultraviolet. The tremendous efficiency of the green line excitation is shown also by the strong green line excitation even when most of the oxygen has been cleaned up.

4. Pair Theories of Meson Scattering. E. NELSON AND J. R. OPPENHEIMER, *University of California.*—With a theory of the interaction of spin one-half mesotrons with nuclei in which the nuclear particle, treated as an extended source of mesotrons, is strongly coupled to the mesotron field, both nuclear scattering of low-energy mesotrons and the range of nuclear forces were found to be independent of the spin dependence of the coupling and to be given by the size of the source. Thus the scattering cross section for spin dependent coupling is the same as that calculated by Weinberg for scalar coupling. If one uses the observed scattering cross section of cosmic ray mesotrons, which is of the order of the square of the Compton wave-length of the proton, to fix the size of the source, one obtains a range of nuclear forces only one-tenth of the observed range, which is of the order of the Compton wave-length of the mesotron. Similar results hold when more than one pair are simultaneously created by the nuclear particle. These results show that it is not possible to reconcile small scattering of mesotrons with the observed range of nuclear forces in a theory involving coupling energies non-linear in the mesotron field.

5. The Primary and Probable Ionization of Helium by Cosmic Rays. WAYNE E. HAZEN, *University of California.*—A cylindrical cloud chamber (30 cm×30 cm) was expanded at random. A magnetic field of about 1000 gauss made possible a determination of momentum. The illumination was at an angle of 45° with the chamber axis and photographs were taken at f10 and 1/200 sec. with a stereoscopic camera. The tracks of ionizing radiation which passed through the chamber within 1/10 sec. after completion of the expansion were photographed as well as the diffuse tracks of pre-expansion radiation. The sensitive time was checked after every four or five expansions with a shuttered x-ray beam and was always greater than 3/10 sec. Under such conditions each dot appearing along the image of a post-expansion track represented a primary ionization event. Since the clearing field of 40 volts per cm was not shorted out, the columns of positive and negative ions in diffuse tracks were well separated and the probable ionization could also be determined.

6. High Energy Scattering of Deuterons by Protons. D. J. BOHM AND ROY THOMAS, *University of California.* (*Introduced by J. R. Oppenheimer.*)—The scattering of high energy protons on deuterons has been investigated for

the range 3–6 Mev of relative kinetic energy using the Born approximation. A complete analytic treatment is possible if the wave functions and potentials are approximated by Gauss functions whose parameters are chosen to give the best fit to available information on the deuteron. It has been found that the tensor forces contribute to the scattering at high angles, and that exchange terms are small but appreciable. Experimental study of the deuteron-proton scattering in this range, especially with regard to angular dependence, would be very desirable because considerable information on the form of the potential well and the types of force present may be obtained by comparison with the calculated values.

7. Further Results on Magnetic Scattering of Neutrons. F. BLOCH AND M. HAMERMESH, *Stanford University, California.*—The scattering and polarization of neutrons passing through iron have been studied using, for the 3*d* shell, a form factor calculated from the tabulated Fe wave-functions of Manning and Goldberg. For the experiment of Alvarez and Bloch, a theoretical effect of 5.1 percent is obtained, in sufficiently good agreement with the experimental result of 6 percent. Extremely large polarization effects are predicted for neutrons of wave-length between 3 and 4A. The effect of the purely magnetic term in the scattering has been examined. The presence of this term leads to a noticeable difference between the scattering of neutrons by specimens at room temperature and above the Curie point, assuming that there the magnetic scattering disappears. Also, this magnetic term is different for unmagnetized and completely demagnetized specimens at any given temperature; it should result in a 25 percent effect in the transmission of neutrons of 4A wave-length through a 4 cm specimen.

8. Angular Distribution in Deuteron Disintegration by Electrons. C. RICHMAN, *University of California.* (*Introduced by J. R. Oppenheimer.*)—In the disintegration of deuterons by electrons, the two effects, corresponding to electric dipole and magnetic dipole photodisintegration of the deuteron, produce their characteristic angular distributions. The electric effect gives approximately a $\sin^2\vartheta$ distribution where ϑ is the angle between the direction of the incident electron and the direction of motion of the proton produced by the collision; the magnetic effect gives a uniform distribution. The complete angular distribution is then of the form $A+B\sin^2\vartheta$, A and B constants for a given energy of electrons. Verification of magnetic disintegration may therefore be obtained through observations of angular distribution. The results of some calculations of A and B for energies not far from the threshold 2.17 Mev are given in the table below. A and B are in units of $10^{-32}d\Omega/4\pi$ cm^2.

Kinetic Energy of Electrons Mev	2.32	2.40	2.50	2.60
A	5.00	9.69	16.6	24.2
B	.877	2.95	8.02	16.4

The range corrections included in these numbers were made on the assumption of a Majorana interaction and a range of $2.80\cdot10^{-31}$ cm.

9. Artificial Radioactivity of Some Rare Earths. C. S. WU AND E. SEGRÈ, *University of California.*—About one year ago we started an investigation of the artificial radioactivity of praseodymium, neodymium and samarium (prepared by Professor Rolla) with a special regard to the possibility of forming radioactive isotopes of element 61. Results were obtained in substantial agreement with those reported by the Ohio group using rare earths of a different author. Some additional assignments were made as follows:

Ce^{141} 16*d*, β^-, $Pr^{141}(n,p)$.
Pr^{140} 3.5 min. β^+ $Pr^{141}(n,2n)$.
Pr^{142} 18.7 hr. β^-, β^- end point 2 Mev no γ.

For the Nd 47 hr. β^-, β^- end point of 0.95 Mev was found in disagreement with the 2.9 Mev found by the Ohio group. Pr+α gives an activity with an apparent half-life of about 200*d*. This is probably the same activity as that found by the Ohio group with a period >100 days. It may reasonably be assigned to an isotope of element 61. The high γ to β ratio suggests *K*-capture or isomeric transition. Absorption measurements give an energy of roughly 670 Kev for the γ-ray. Similar long life rays are shown by deuteron bombarded neodymium. We could not find the 19 hr. activity induced by α on Pr reported by the Ohio group. Samarium bombarded with neutrons shows a 47 hr. period due to an isomeric transition as shown by the characteristic x-rays of Sm emitted.

10. Radiations from Radioactive Gold, Tungsten and Dysprosium. ARNOLD F. CLARK, *University of Indiana.**—By use of a Geiger-Mueller tube counter, both beta-gamma and gamma-gamma coincidences were found associated with the 2.7 day Au^{198}, the 24 hr. W^{187} and the 2.5 hr. Dy^{165} activities. The results show that the beta-ray spectrum of gold is simple, with an absorption end point of 0.78 Mev. The efficiency of the gamma counter indicates that this decay is followed by the 0.44 and 0.28 Mev gamma-rays in cascade.[1,2] Tungsten beta-rays with energies greater than 0.5 Mev give no beta-gamma coincidences, which shows that the beta spectrum is complex. The high energy beta group, with a maximum energy of 1.4 Mev,[3] evidently leaves the residual nucleus in the ground state. Roughly 40 percent of the beta-rays belong to the low energy group. The maximum energy gamma-ray measures 0.9 Mev; however, the gamma-gamma coincidences indicate that there are other gamma-rays in parallel with the 0.9 Mev transition. The maximum energy gamma-ray from the dysprosium activity is 1.1 Mev. In this case the coincidence results were only qualitative.

* Now at the Radiation Laboratory, University of California, Berkeley.
[1] J. R. Richardson, Phys. Rev. **55**, 609 (1939).
[2] Folke Norling, Arkiv for Mat., Astr. och Fysik **27**, B. 9 (1941).
[3] Fajans and Sullivan, Phys. Rev. **58**, 276 (1940).

11. Gamma-Rays from Radioactive Mercury. A. C. HELMHOLZ, *Department of Physics, Radiation Laboratory, University of California, Berkeley.*—The electron lines from radioactive mercury formed by the deuteron bombardment of gold have been investigated with a β-ray spectrograph. The activities have been studied by Wu and Friedlander,[1]

and the samples were kindly supplied by them. K, L, and M conversion lines from two γ-rays, and L and M from a third have been observed. Successive exposures showed the first two to follow the 25 hr. period, the third the 64 hr. period. The energies are 161, 130, and 75 kev, in fair agreement with lines previously reported by Valley.[2] In the case of the first two γ-rays the L conversion is more intense than the K. This may indicate γ-rays of high multipole order. The fact that Wu and Friedlander found that all three of these γ-rays are emitted by Au^{197}, to which both the 25 hr. and 64 hr. periods decay, also indicates large possible spin changes.

[1] C. S. Wu, G. Friedlander, Phys. Rev. in press.
[2] G. E. Valley, Phys. Rev. **60**, 167 (1941).

FRIDAY AFTERNOON AT 1:30 O'CLOCK

12. Theory of Intensity and Polarization of Continuous X-Radiation. ROBERT WEINSTOCK, *Stanford University.* (*Introduced by F. Bloch.*)—One computes the probability that an electron moving toward an atom with velocity v_1 be deflected through a given angle θ with asymptotic velocity v_2, having experienced an energy loss $h\nu$. These dipole matrix elements of the single process have been rigorously computed by Sommerfeld,[1] but the necessary incoherent integration over all polar angles (θ, ϕ) of scattering of the incident electron has not in general been calculated in closed form. This is carried out by means of a series expansion; the resulting integrated series converges with sufficient rapidity to be suitable for numerical computation of any order of accuracy. One is thereby able to answer principal questions as to intensity and polarization of continuous x-radiation. The assumptions of an infinitely thin target, negligible retardation and relativity, and a pure Coulomb field as seen by the incident electron during emission, are made. Comparison with the absolute intensity measurement of Smick and Kirkpatrick[2] was good only as to order of magnitude, the disagreement being by a factor of 2.8. The agreement with the relative intensity measurements of Haworth and Kirkpatrick[2] is completely satisfactory.

[1] Ann. d. Physik **11**, 257 (1931).
[2] Phys. Rev. **60**, 162–163 (1941).

13. The Value of the Faraday. RAYMOND T. BIRGE, *University of California.*—The best voltameter value of the Faraday F appears to be $96{,}488 \pm 10$ abs. coul. (chemical scale), but many persons distrust this result, because of the numerous sources of systematic error (known and unknown) inherent in all voltameter work. One may, however, obtain a number of values of F, completely independent of voltameter work, since certain $f(e, m, h)$ involve F, and others do not. A systematic treatment of all such data now leads to new weighted average values of F ranging from 96,502 to 96,516, depending on the weightings adopted. The probable error of the weighted average, in each case, is approximately 12 coulombs. An assumed value $F = 96{,}516$ abs. coul. almost completely eliminates the present small discrepancies between certain types of determination of e/m, and leads to $1.7595_6 \pm 0.0001_6$ as the new weighted average. It raises e only from 4.8025 to 4.8039 ($\times 10^{-10}$), with no change in the probable error of ± 0.001 (see Abstract No. 21). This new evidence thus shows that the present voltameter value of F is unlikely to be in error by more than 30 coulombs, although an increase in value of roughly this amount would significantly improve the consistency of certain $f(e, m, h)$.

14. Regulated Voltage Supplies. L. MARTON, *Stanford University.*—The requirements for constancy of voltage supplies of magnetic electron microscopes are very high (1 part in 10,000 or better). These requirements have been satisfied up to now either (1) by the use of large capacitors on the high voltage side, (2) by the use of special power supplies for the primary (motor generators or saturated core regulators), and (3) by regulated circuits operating on the feedback principle. In principle a regulation of the power supply can be avoided by sending the electron beam through a very stable magnetic analyzer (monochromator) and using the exit aperture as a new source of electrons. Experience shows however that secondary effects (variable charges on different parts of the microscope, etc.) may prevent stable operation, if the beam current is varying too much. Such effects can be avoided by using non-regulated power supplies for the acceleration of the electrons to almost the full value of their speed and adding a last stage of acceleration compensating the fluctuations of the previous stages. Such a last stage can be made, for instance, by sending the accelerated beam itself through a magnetic analyzer and using the deviations from a pre-set value to operate the last stage through an amplifier.

15. Non-Laue Reflections from Various Crystals. DONALD S. TEAGUE, *Stanford University.* (*Introduced by Paul Kirkpatrick.*)—With a photographic spectrometer attempts were made to observe reflections of molybdenum K radiation at incidence angles near but not identical to the Bragg angles (modified reflection, diffuse reflection), using crystals of iron, zinc blende, barite, calcite, Rochelle salt, and quartz. The order given is one of increasing crystal perfection. As crystal perfection increased, the range of angles of incidence over which line reflection could be observed decreased steadily from several degrees to about two minutes. With the most imperfect crystals, iron and zinc blende, no evidence of inconstancy in the angle of deviation of a monochromatic reflection was observed. With barite, calcite and Rochelle salt the inconstancy was readily observed, while with quartz, the most perfect

crystal used, the usable range of angles of incidence was so short as to prevent observation of the shift, if it existed. In all observed cases, this shift was in the sense required by the theory of diffuse scattering,[1] and had magnitudes in agreement with the theory or somewhat higher.

[1] S. Siegel and W. H. Zachariasen, Phys. Rev. **57**, 795 (1940).

16. Quantization of the Wave Field for Particles with Spin 3/2. S. KUSAKA AND J. WEINBERG, *University of California.*—Using the formulation of the theory of particles with spin 3/2 developed by Rarita and Schwinger,[1] we have quantized the wave field in the presence of static external electromagnetic field. The quantization was carried out according to Fermi-Dirac statistics by the method of Snyder and Weinberg,[2] i.e., by demanding that the occupation numbers of the normal modes of the wave field have eigenvalues 0 and 1. It is shown that the commutator of the wave field and its canonical conjugate, taken at the same time, is equal to the projection operator which restricts the wave field to a function satisfying the supplementary conditions. This projection operator has been calculated and found to be a point operator containing the delta function and its first and second derivatives, and to be a gauge invariant function of the electromagnetic field. It follows from this that the charge densities at two points outside each others' light-cone commute. The problem for spin 2 and the general theory for higher spins are now being investigated.

[1] W. Rarita and J. Schwinger, Phys. Rev. **60**, 61 (1941).
[2] H. Snyder and J. Weinberg, Phys. Rev. **57**, 307 (1940).

17. Applications of the Multiharmonograph to the Graphical Solution of Physical and Mathematical Equations. S. LEROY BROWN, *The University of Texas.*—A multiharmonograph with thirty harmonic elements has been found to have a great variety of applications ranging from simple synthesis and harmonic analysis to the graphing of Legendre polynomials and the solution of thirtieth-degree equations. The machine is essentially a synthesizer with fifteen sine components and fifteen cosine components, but so arranged that either the sum of all the components may be plotted against the angle or one set of components may be plotted at right angles to the other set. In addition, the epoch angle of each component is adjustable as well as its amplitude. In general, the function to be graphed or equation to be solved is transformed into a harmonic form by trigonometric substitution, DeMoivre's theorem, or expansion into a power series and then transformed to the harmonic form. The machine has practical application to harmonic synthesis, harmonic analysis, determination of the real and complex roots of polynomials, representation of polar equations, solution of certain types of non-linear simultaneous equations, solution of transcendental functions, graphing of Legendre's polynomials (and associated Legendre's polynomials), and the graphing of certain types of trigonometric equations encountered in the determination of parameters in crystal structure.

18. Negative Point-to-Plane Corona in Air. GILBERT G. HUDSON, *Department of Physics, University of California.*—The regular relaxation oscillator-like pulses observed by Trichel[1] in room air could not be obtained with clean, smooth points until the discharge had been run for thirty minutes or so. Microscopic examination of the point showed that a few dust specks (about 0.01 mm diameter) had been collected near the tip. A clean point dusted with MgO powder was then found to give regular pulses at once. Even in dry air, where the irregular pulses were first observed, the Trichel pulses were produced for the short time during which the specks remained on the point. The electrons emitted from these particles by a process such as the Paetow[2] effect initiate a new pulse as soon as the inhibiting negative ions have been swept out of the region near the point. These triggering electrons thus insure the periodicity of the pulses. Pitting of the Pt point was observed, and the formation of oxide deposits by the discharge was also indicated. A pre-onset discharge was seen to take place from larger oxide particles favorably located near the tip.

[1] G. W. Trichel, Phys. Rev. **54**, 1078 (1938).
[2] H. Paetow, Zeits. f. Physik **111**, 770 (1939). See also L. B. Loeb, "Fundamental Processes of Electrical Discharge," p. 498.

19. Properties of Coronas in Pure and Impure H_2, N_2 and A. GERHARD L. WEISSLER, *University of California.*—Studies were made on very pure Hg free electron free gases H_2 and N_2, and on A which differs from these by having metastable states. Streamer formation requires adequate photo-ionization. Either burst pulses in positive corona or Trichel pulses in negative corona require respectively heavy positive and negative space charges. In H_2, N_2 and A negative ions cannot form and negative Trichel pulses are not observed. Photo-ionization is weak in N_2 and H_2 and streamer formation occurs only at higher fields; burst pulses are not observed. Pure argon shows no corona but gives sparks on positive and arcs on negative points, owing to intense photo-ionization of metastables. Addition of N_2 or H_2 destroying metastables permits streamers and burst pulses to form on the positive point. It changes the arc to a corona on the negative point but gives no Trichel pulses. Less than 0.1 percent O_2 in all gases restores Trichel pulses, preonset and onset streamers and burst pulses. Clean-up by negative corona discovered by W. H. Bennett[1] is shown to be caused by formation and adsorption of water vapor. The etching of points reported by W. H. Bennett occurs in pure gases and appears to be some sort of a sputtering process.

[1] W. H. Bennett, Phys. Rev. **58**, 992 (1940).

SUPPLEMENTARY PROGRAM

20. Regulated Power Supplies. L. MARTON AND R. G. E. HUTTER, *Stanford University.*—For different branches of physics regulated power supplies are becoming more and more important. Many designs have been proposed in the last few years, some of them operated by means of negative feedback.[1,2] By a mathematical analysis of such circuits the limitation of regulation (current or voltage-regulation) can be located to some elements of the circuit. As a result of such analysis a better design is proposed with very much improved constancy for normal line fluctuations and load variations. The improved circuit uses a single stage of negative feedback and a special voltage regulation in the screen grid circuit of the D-C amplifier. The influence of the changes in input can be completely compensated for any arbitrary setting of the output. The experiments show excellent agreement with the calculations.

[1] H. S. Black, Bell System Tech. Jour. **13**, 1 (1934).
[2] A. W. Vance, R. C. A. Rev. **5**, 293 (1941).

21. The Value of the Electronic Charge. RAYMOND T. BIRGE, *University of California.*—(1) The present best weighted average for the viscosity of air is $\eta_{23}=(1832.5\pm1.0)\times10^{-7}$. This value, combined with a weighted average of all oil-drop work, gives $e=(4.8117\pm0.0057)\times10^{-10}$. (2) From the properties of calcite and grating wave-lengths of x-rays, $N_0=(6.0228_2\pm0.0011)\times10^{23}$, and $e=F/N_0=4.8025\pm0.0010$. (3) The possibility of large unsuspected errors in the adopted voltameter value of F seems to be excluded by the results of Abstract No. 13. The new *independent* values of F give $e=4.8034$ to 4.8039, with a probable error of ±0.0011. (4) From a least squares solution of *all* $f(e, m, h)$ *not* involving F, one obtains $e=4.80376$ to 4.80386, according to the weighting, with a probable error of ±0.002. Since this last evaluation is completely independent of the properties of calcite, as well as of F, it appears to eliminate the possibility of any significant error in e due to imperfect crystal structure of calcite, in agreement with DuMond and Bollman's 1936 results. A probable error of ±0.002, applied to some value of e between 4.8025 and 4.8035, should thus represent adequate allowance for these suggested sources of systematic error.

22. Production of Mesotrons, "Stars," Cascade Showers Produced by Penetrating Rays, Slow Protons, Evidence for the Disintegration Electron. WILSON M. POWELL,* *Kenyon College, Gambier, Ohio.*—In 2512 cloud-chamber photographs made at random at 14,125 feet there appear 1,085 particles that penetrate 2 cm or more of lead without producing secondaries. There are 458 particles that show heavy ionization, 35 protons that stop in the chamber, 19 mesotrons stopping in the chamber, 10 of which show an accompanying track that can be interpreted as the disintegration electron. Nine particles in addition give questionable evidence of being mesotrons with accompanying disintegration electrons. Six particles might be interpreted as protons. Three showers appear to be produced by heavy particles. Two mesotrons are produced in the chamber. Ninety-seven showers of more than 6 particles appear.

* Guggenheim Fellow at the University of California.